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IMEC IMPLEMENTATION IN TARSLLS

OPERATIONS ANALYSIS DEPARTMENT

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IMEC IMPLEMENTATION IN TARSLLS

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REPORT 164

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ABSTRACT

This analysis develops and evaluates alternative procedures which use Item Mission Essentiality Codes (IMECs) in determining Tender and Repair Ship Load List (TARSLL) range and depth. These procedures include separate net requisition effectiveness goals by IMEC, minimum protection levels by IMEC for depth determination, and weights by IMEC in the risk equation. The study evaluates the impact these procedures have on TARSLL range, cost and effectiveness. We recommend eliminating the current essentiality term from the TARSLL model risk equation. We also recommend computing the TARSLL depth using the Geometric/Exponential distribution with no range cut and separate gross requisition effectiveness goals by IMEC category.

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EXECUTIVE SUMMARY

1. Background. Almost every ship installed item is currently coded "vital" to the ship's mission, thus it is almost impossible for the Tender and Repair Ship Load List (TARSLL) model to distinguish between the most essential items and the other less important candidates. The TARSLL currently attempts to distinguish between items in two ways: (1) for items with historical demand, the item's Quarterly Average Demand (QAD) is used as a measure of essentiality, and (2) for items without historical demand, an essentiality value is computed based on the item's ship and tender MEC and population. A new measure of essentiality, Item Mission Essentiality Codes (IMECs), more ably differentiates essentiality between items. IMECs are computed from an item's Military Essentiality Code (MEC) and the equipment's Mission Criticality Code (MCC).

2. Objective. To evaluate alternative procedures which use IMECs in determining TARSLL range and depth for both destroyer tender/repair ship (AD/AR) loads and attack submarine (AS) loads.

3. Approach. We evaluated the following techniques: separate net requisition effectiveness goals by IMEC, range cuts by IMEC, minimum protection levels by IMEC for depth determination, and weights by IMEC in the risk equation. We built test load lists for the AS-11 using hull-tailored IMECs, and for the AD-44 using system IMECs. Hull-tailored IMECs represent the highest IMEC across all applications installed on supported ships, while system IMECs represent the highest IMEC across all Navy applications. We evaluated the test loads by matching them against 90 days of Mobile Logistic Support Force (MLSF) demand data and analyzing their impact on range, dollar value, and effectiveness.

4. <u>Findings</u>. For both the AS and AD/AR test loads, the range cuts by IMEC option was not cost-effective. Minimum protection level by IMEC was not cost-effective for the AS test load, but provided similar results as the benchmark for the AD test load. Weights in the risk equation of 1.0, 0.5, 0.1, and 0.01 for IMECs 4, 3, 2, and 1, respectively, were not cost-effective for either ship, while the weights of 4.0, 3.0, 2.0, and 1.0 for IMECs 4, 3, 2, and 1, respectively, provided similar results as the benchmark for the AS but were not cost-effective for the AD test load.

Goals by IMEC was the most cost-effective alternative common to both test ships. The AS load list built using the wholesale levels goals by IMEC resulted in a $.2M increase over the current load with a zero to one percentage point increase in effectiveness, and up to a two percentage point increase across IMEC categories. The AD/AR load list resulted in the same dollar value and gross requisition effectiveness as the benchmark, and up to a one percentage point increase across IMEC categories.

For each IMEC, we graphed net requisition effectiveness versus dollar value to determine what would be the most cost-effective goal by IMEC for each ship. The graphs indicated that separate net requisition goals by IMEC of 90% for IMEC 1 and 2 items and 95% for IMEC 3 and 4 items are the most cost-effective goals for the AS, and separate net requisition goals by IMEC of 95% for each IMEC are the most cost-effective goal for the AD/AR. Compared with the current load list, these separate effectiveness goals gave a one percentage point increase in effectiveness for the AS with an $.8M increase in dollar value, and a one percentage point increase in effectiveness for the AD/AR with no change in dollar value. More significantly, these separate goals by IMEC gave up to a four percentage point increase in individual IMEC effectiveness for both ships.

Based on the findings in reference 6 of APPENDIX A, we built load lists using the Poisson/Normal and Geometric/Exponential distributions instead of the Normal distribution. The combination of the wholesale level goals by IMEC with the Poisson/Normal distribution is less expensive than the current benchmark but gives lower effectiveness.

The combination of the wholesale level goals by IMEC with the Geometric/Exponential distribution increased effectiveness up to six percentage points across IMECs over the current benchmark with a \$.8M decrease in dollar value for the AS-11 and increased effectiveness up to two percentage points across IMECs with a \$.5M decrease in dollar value for the AD/AR.

Using the most cost-effective goals by IMEC with the Geometric/Exponential distribution resulted in an increase of effectiveness across IMECs over the current benchmark of up to nine percentage points with a \$.2M increase in dollar value for the AS-11 and increased effectiveness across IMECs up to eight percentage points with a \$2.M decrease in dollar value for the AD/AR.

5. Conclusions. The most cost-effective method for implementing the new IMEC essentiality measure into TARSLL computations is goals by IMEC. This method also provides the greatest flexibility to allocate dollar resources to more essential items. Using the goals by IMEC with the Geometric/Exponential distribution provides an even greater increase in effectiveness.

6. Recommendation. We recommend eliminating the current essentiality term from the risk equation in the TARSLL model. We also recommend computing the TARSLL depth using the Geometric/Exponential distribution with no range cut and separate gross requisition effectiveness goals by IMEC category.

I. BACKGROUND

A tender's load list cannot include every item which might be needed by one of the ships it supports. Load list costs, tender space constraints and other factors limit the range and depth of items a tender can carry. Because of these limitations, every effort is made to insure that the items on the load are the ones most essential to the supported ships. Unfortunately, current procedures to identify the most essential load list candidate items do not work. Almost every item is coded "vital" to the ship's mission. Since almost all items have the same essentiality code, it is impossible to distinguish between the most essential items and the other less important candidates. In short, up to this time there has been no method available which can accurately grade Tender and Repair Ship Load List (TARSLL) candidates according to their essentiality to a ship's mission.

A new measure of essentiality, Item Mission Essentiality Codes (IMECs), has recently been introduced. TABLE I shows the definitions for each IMEC value.

TABLE I
IMEC DEFINITIONS

IMEC	Definition
1	Lack of item causes minor mission impact
2	Lack of item results in loss of secondary mission capability
3	Lack of item results in severe degradation of primary mission capability
4	Lack of item causes total loss of primary mission capability
5	Item related to life support or personnel safety

IMECs are based on an item's Military Essentiality Code (MEC) and Mission Criticality Code (MCC). MECs define the importance of a part to the equipment in which it is installed and are assigned values of 1 (vital), 3 (nonvital), or 5 (safety). MCCs are based on historical Casualty Reporting (CASREP) data and reflect an equipment's essentiality to the ship's mission. MCCs are assigned values from 1 to 4. TABLE II shows the IMEC derivation.

TABLE II
IMEC DERIVATION

MEC	MCC	IMEC
1	1	1
1	2	2
1	3	3
1	4	4
1	Other	1
3	All Values	1
5	All Values	5

Reference 1 of APPENDIX A tasked the Navy Fleet Material Support Office (FMSO) to develop and evaluate alternative procedures which use IMECs in computing TARSLL range and depth. This study included both destroyer tender/repair ship (AD/AR) loads and attack submarine (AS) loads.

Reference 2 of APPENDIX A was held to discuss various methods of using IMECs in TARSLL computations. As a result of the meeting, we agreed to (1) use the highest hull-tailored IMEC across all applications vice the average, (2) eliminate current depth constraints on items without demand as described in reference 3 of APPENDIX A, (currently, these constraints limit the depth for items with no historical demand (Best Replacement Factor (BRF) items) to a quantity of 50 units and the extended dollar value to $100), and (3) retain on the new load list all previous load list items that had at least one demand during the selected two year period or had at least one equipment application on the new load list configuration, as described in reference 4 of APPENDIX A.

II. APPROACH

A. DATA. The test load lists were built using an AS-11 candidate file including demand from February 1983 through January 1985, and an AD/AR candidate file including demand from July 1983 through June 1985. The load lists were then evaluated by matching them against Mobile Logistic Support Force (MLSF) demand data for a subsequent 90 day period (1 February 1985 to 30 April 1985 for the AS-11 and 1 July 1985 to 30 September 1985 for the AD-44).

The AD/AR TARSLL is ocean-tailored; i.e., every tender in the Atlantic ocean receives the same load and every tender in the Pacific ocean receives the same load. To obtain IMECs for the AD/AR candidates, we matched the candidate records by National Item Identification Number (NIIN) against a Navy Ships Parts Control Center (SPCC) file containing the wholesale IMEC; i.e., the highest IMEC across all applications. The candidates that were unmatched (7.8%) were assigned an IMEC of 1. Fourteen percent of the candidates had IMECs equal to 5, which we combined with IMEC 4.

The AS TARSLL is a hull-tailored load list; i.e., it supports a specified mix of submarines. Therefore, we did not use the wholesale IMEC. Instead, we computed each item's IMEC as a combination of the MEC and MCC for the equipments installed on the supported submarines. The MCC used was the highest value for the Allowance Parts List (APL). Twenty-four percent of the records had nonnumeric or missing MCCs. In these cases, the IMEC was set equal to 1.

No MEC 5s were in the AS-11 candidate file.

TABLE III shows the distribution of IMECs by candidate demands and TABLE IV shows the distribution of IMECs by candidate items. More detailed IMEC distributions by Cog are in APPENDIX B.

TABLE III
DISTRIBUTION OF IMECs BY CANDIDATE DEMANDS

	IMEC	% NIIN	% REQN	% UNIT
AS-11	1	62	71	73
	2	7	5	5
	3	14	10	13
	4	17	14	9
AD/AR	1	33	42	62
	2	7	7	3
	3	15	12	17
	4	45	39	18

TABLE IV
DISTRIBUTION OF IMECs BY CANDIDATE ITEMS

	IMEC	# NIIN	% NIIN
AS-11	1	47,244	43
	2	19,984	18
	3	25,415	23
	4	18,210	16
AD/AR	1	53,820	23
	2	41,704	18
	3	76,319	33
	4	60,933	26

B. ALTERNATIVES. We evaluated alternative benchmarks in terms of adjustments to the risk equation. These alternative benchmarks as well as techniques for implementing IMECs are described in this section.

1. <u>Benchmark Alternatives</u>. Currently, the risk equation for BRF items uses an essentiality based on the item's vital/nonvital MEC, ship installability, and population. A distribution of this current essentiality measure for both test ships is shown in APPENDIX C. Because current measures of essentiality do not adequately differentiate between items, NAVSUPSYSCOM proposed an alternative benchmark that uses the Quarterly Average Demand (QAD) in the denominator of the risk equation for both demand and BRF items. Since the IMEC replaces the current essentiality, we also considered another alternative benchmark that eliminates the current essentiality measure from the risk equation for BRF items. TABLE V shows the risk equations for each of these benchmarks.

TABLE V
RISK EQUATIONS

	DEMAND ITEMS	BRF ITEMS
CURRENT	$= \frac{(\lambda)(C)(A)}{QAD}$	$= \frac{(\lambda)(C)}{E}$
NAVSUPSYSCOM PROPOSAL	$= \frac{(\lambda)(C)(A)}{QAD}$	$= \frac{(\lambda)(C)}{(E)(QAD)}$
NO ESSENTIALITY FOR BRF ITEMS	$= \frac{(\lambda)(C)(A)}{QAD}$	$= (\lambda)(C)$

where

λ = control parameter adjusted to achieve specified effectiveness goal

C = unit price

A = average requisition size

QAD = quarterly average demand

$$E = \frac{(POP_s)(E_s) + (POP_t)(E_t)}{\Sigma POP}$$

where

POP_s = ship installable population

E_s = ship MEC smoothed to a value between 0 and 1

POP_t = tender installable population

E_t = tender MEC smoothed to a value between 0 and 1

$POP = POP_s + POP_t$

2. Separate Effectiveness Goals by IMEC. The TARSLL is currently built to meet an 85% net requisition effectiveness goal. We tested the NAVSUPSYSCOM recommended goals by essentiality category shown in TABLE VI, Set I. The Set I goals are identical to the goals approved by the Chief of Naval Operations (CNO) for the wholesale level, reference 5 of APPENDIX A. The Set II goals were developed as the most cost-effective goals.

TABLE VI
EFFECTIVENESS GOALS BY IMEC

IMEC	NET REQUISITION EFFECTIVENESS GOALS		
	SET I AS-11 & AD/AR	SET II AS-11	SET II AD/AR
1	85%	90%	95%
2	87%	90%	95%
3	90%	95%	95%
4	92%	95%	95%

We built all other load lists for the current overall net requisition effectiveness goal of 85%.

3. <u>Range Cuts by IMEC</u>. As described earlier, we retained on the new load list all items from the previous load list which still had application (i.e., APL still on supported ships) or had at least one demand in the last two years. For the remaining candidates, we tested the range cuts shown in TABLE VII.

TABLE VII
RANGE CUTS BY IMEC
(DEMANDS PER EIGHT QUARTERS)

ALTERNATIVE	IMECS 1 AND 2	IMECS 3 AND 4
1	0.5	0.0
2	1.0	0.0
3	1.0	0.5
4	2.0	0.5
5(AS-11 only)	5.0	3.0
6(AD/AR only)	8.5	6.0

Currently, the range cuts are 4.0 for the AS and 8.5 for the AD/AR load lists. The first four alternatives were specified by NAVSUPSYSCOM. Alternatives 5 and 6 were added to approximate current range.

4. <u>Minimum Protection Level by IMEC for Depth Determination</u>. The current minimum protection level is 2.275%. We tested a minimum protection level of 50% for IMEC 3 and 4 items.

5. <u>Weights by IMEC in Risk Equation</u>. We tested applying the weights in TABLE VIII to the risk equation. Set I was proposed by NAVSUPSYSCOM, while Set II was developed to come closer to current effectiveness levels.

TABLE VIII
WEIGHTS IN RISK EQUATION

IMEC	WEIGHTS	
	SET I	SET II
1	.01	1.00
2	.10	2.00
3	.50	3.00
4	1.00	4.00

C. <u>PERFORMANCE MEASUREMENTS</u>. The performance measurements used to evaluate the load lists were range, dollar value, and effectiveness. To measure alternative effectiveness, the computed load lists were compared with 90 days of actual demand. The effectiveness was computed in the two ways shown below.

$$\text{GROSS REQUISITION EFFECTIVENESS} = \frac{\#\ \text{REQUISITIONS SATISFIED}}{\#\ \text{REQUISITIONS FOR LL} + \text{C} + \text{N}}$$

$$\text{MODEL REQUISITION EFFECTIVENESS} = \frac{\#\ \text{REQUISITIONS SATISFIED}}{\#\ \text{REQUISITIONS FOR LL} + \text{C}}$$

where

LL = load list items

C = candidates not on load list

N = noncandidates

Gross requisition effectiveness represents the effectiveness the ship would experience since it also considers demand for noncandidates. Model requisition effectiveness measures how well the model performs in selecting the range and depth of candidate items.

III. FINDINGS

A. <u>BENCHMARKS</u>. We built one load using the NAVSUPSYSCOM proposed risk equation and one load using a risk equation with all weights removed for BRF items (OAD and E). The results are shown in TABLES IX and X.

TABLE IX
AS-11 BENCHMARKS

ALTERNATIVE	IMEC	RANGE	$ VALUE	GROSS REQN EFF	MODEL REQN EFF
I. CURRENT	TOTAL	21,551	9.5M	69%	82%
	1	9,817	2.9M		86%
	2	2,178	1.1M		65%
	3	4,899	3.4M		67%
	4	4,657	2.2M		84%
II. NAVSUP-SYSCOM PROPOSED	TOTAL	21,551	9.3M	64%	77%
	1	9,817	2.6M		79%
	2	2,178	1.1M		62%
	3	4,899	3.4M		65%
	4	4,657	2.2M		81%
III. NO ESSENTIALITY	TOTAL	21,551	9.4M	68%	81%
	1	9,817	2.8M		84%
	2	2,178	1.1M		64%
	3	4,899	3.4M		67%
	4	4,657	2.2M		83%

TABLE X
AD/AR BENCHMARKS

ALTERNATIVE	IMEC	RANGE	$ VALUE	GROSS REQN EFF	MODEL REQN EFF
I. CURRENT	TOTAL	19,033	3.3M	33%	49%
	1	4,901	.5M		46%
	2	1,879	.2M		69%
	3	5,000	1.0M		65%
	4	7,253	1.5M		44%
II. NAVSUP-SYSCOM PROPOSED	TOTAL	19,033	3.2M	30%	45%
	1	4,901	.5M		41%
	2	1,879	.2M		58%
	3	5,000	1.0M		61%
	4	7,253	1.5M		42%
III. NO ESSENTIALITY	TOTAL	19,033	3.3M	33%	49%
	1	4,901	.5M		45%
	2	1,879	.2M		69%
	3	5,000	1.0M		65%
	4	7,253	1.5M		44%

The load lists built using the NAVSUPSYSCOM proposed risk equation decreased gross requisition effectiveness three to five percentage points from the current procedures for approximately the same cost. Eliminating the current essentiality measure had almost no impact on effectiveness or cost proving the uselessness of current essentiality measures.

B. ALTERNATIVES. TABLE XI shows the results of the test loads built for the AS-11. Benchmark III refers to the load list built using the risk equation which eliminates the weights QAD and E for BRF items. All alternatives, except the weights by IMEC, use the same risk equation as Benchmark III. The alternative of setting weights by IMEC uses the same risk equation as Benchmark III with an added weight by IMEC in the denominator for both demand and BRF items.

TABLE XI
AS-11 ALTERNATIVES

ALTERNATIVE	RANGE	$ VALUE	GROSS REQN EFF	MODEL REQN EFF
BENCHMARK III	21,551	9.4M	68%	81%
GOALS BY IMEC (Set I)	21,551	9.7M	69%	83%
RANGE CUTS (RC) BY IMEC IMEC = 1,2 / IMEC = 3,4				
RC = 0.5 RC = 0.0	63,176	52.9M	71%	86%
RC = 1.0 RC = 0.0	60,012	50.4M	71%	85%
RC = 1.0 RC = 0.5	36,706	20.9M	71%	85%
RC = 2.0 RC = 0.5	33,747	18.9M	71%	84%
RC = 5.0 RC = 3.0	21,993	9.9M	68%	82%
MIN PROT LEVEL BY IMEC	21,551	9.8M	68%	81%
WEIGHTS BY IMEC I=4, 3, 2, 1				
WT=1,.5,.1,.01	21,551	9.7M	66%	79%
WT=4, 3, 2, 1	21,551	9.3M	67%	80%

The range cuts by IMEC gives the best effectiveness, but the resulting range and dollar values are too large. We tried to get a range closer to the benchmark by using range cuts of 5 (IMEC 1 and 2) and 3 (IMEC 3 and 4). With these range cuts, the dollar value was $.5M higher than the benchmark with no change in gross effectiveness.

The alternative with the next highest effectiveness values was goals by IMEC. Effectiveness was one percentage point higher than the benchmark. The dollar value was $.3M higher than the benchmark.

Minimum protection levels by IMEC was not cost-effective because the effectiveness remained the same as the benchmark while the dollar value increased.

The weights by IMEC of 1.0, 0.5, 0.1, and 0.01 in the risk equation for IMECs 4, 3, 2, and 1, respectively, were also not cost-effective because of the decrease in effectiveness and increase in dollar value over the benchmark. We then tried weights of 4.0, 3.0, 2.0, and 1.0 in the risk equation for IMECs 4, 3, 2, and 1, respectively. The dollar value decreased by $.1M while the effectiveness decreased one percentage point.

TABLE XII shows the results of the load lists built for the AD/AR. The alternatives were the same as the AS-11 alternatives, except that the added range cuts by IMEC were 8.5 (IMEC 1 and 2) and 6 (IMEC 3 and 4).

TABLE XII
AD/AR ALTERNATIVES

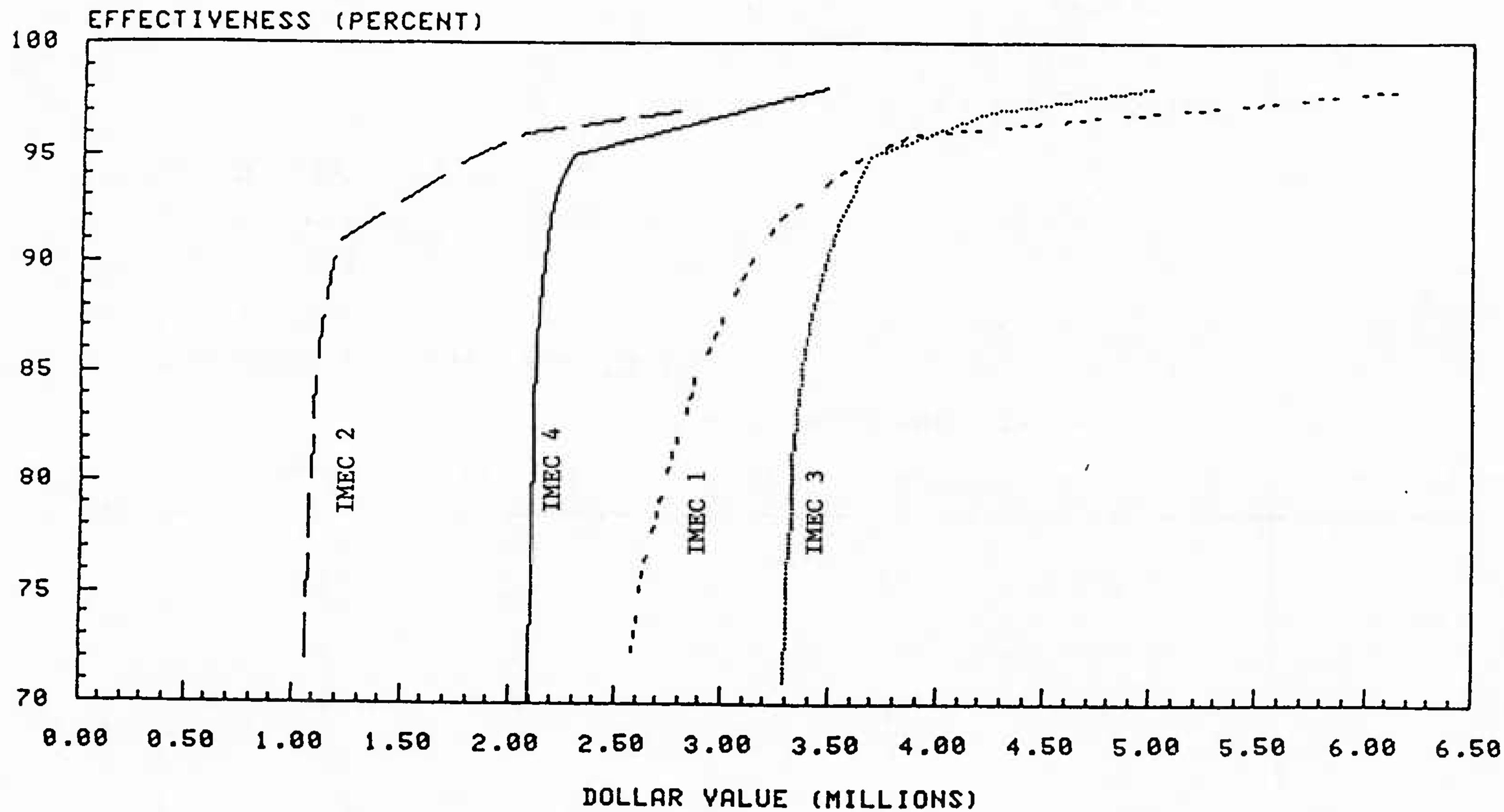
ALTERNATIVE	RANGE	$ VALUE (Millions)	GROSS REQN EFF	MODEL REQN EFF
BENCHMARK III	19,033	3.3	33%	49%
GOALS BY IMEC (Set I)	19,033	3.3	33%	50%
RANGE CUTS BY IMEC IMEC=1,2 IMEC=3,4				
RC = 0.5 RC = 0.0	151,161	110.2	36%	53%
RC = 1.0 RC = 0.0	146,541	107.3	36%	53%
RC = 1.0 RC = 0.5	55,778	21.1	35%	53%
RC = 2.0 RC = 0.5	51,979	19.0	35%	53%
RC = 8.5 RC = 6.0	20,990	3.8	33%	50%
MIN PROT LEVEL BY IMEC	19,033	3.3	33%	49%
WEIGHTS BY IMEC I=4, 3, 2, 1				
WT=1,.5,.1,.01	19,033	3.3	30%	45%
WT=4, 3, 2, 1	19,033	3.3	32%	48%

Looking at effectiveness alone, the range cuts by IMEC option gave the best results, but once again the range and dollar values were too high. Applying range cuts of 8.5 for IMEC 1 and 2 items and 6.0 for IMEC 3 and 4 items increased the dollar value by $.5M with no change in gross effectiveness.

The dollar values for each of the remaining alternatives were all the same as the benchmark. The weights by IMEC option resulted in decreased effectiveness values from the benchmark. Both the goals by IMEC and minimum protection level options gave similar or better effectiveness values as the benchmark, proving most cost-effective. Of the two, goals by IMEC gave higher model effectiveness.

In summary, it is possible to achieve similar results with any alternative by adjusting parameters. The AS-11 is slightly more sensitive to alternatives tested than the AD/AR. Goals by IMEC is the most cost-effective alternative common to both test ships, is easier to use than the other alternatives, and provides greater flexibility to adapt to changing resource allocations.

C. IMEC GOALS. The original goals tested were the same as the goals approved by CNO for the wholesale level. We also attempted to determine if there are more appropriate goals in terms of cost-effectiveness. The following graphs (FIGURES 1 and 2) show dollar value versus predicted net requisition effectiveness for each IMEC category. The graphs indicate that there is little or no change in dollar value for increases in effectiveness up to the point where the curves begin to level out. The most cost-effective goals by IMEC are at the "knee" of each curve and are listed under each graph.

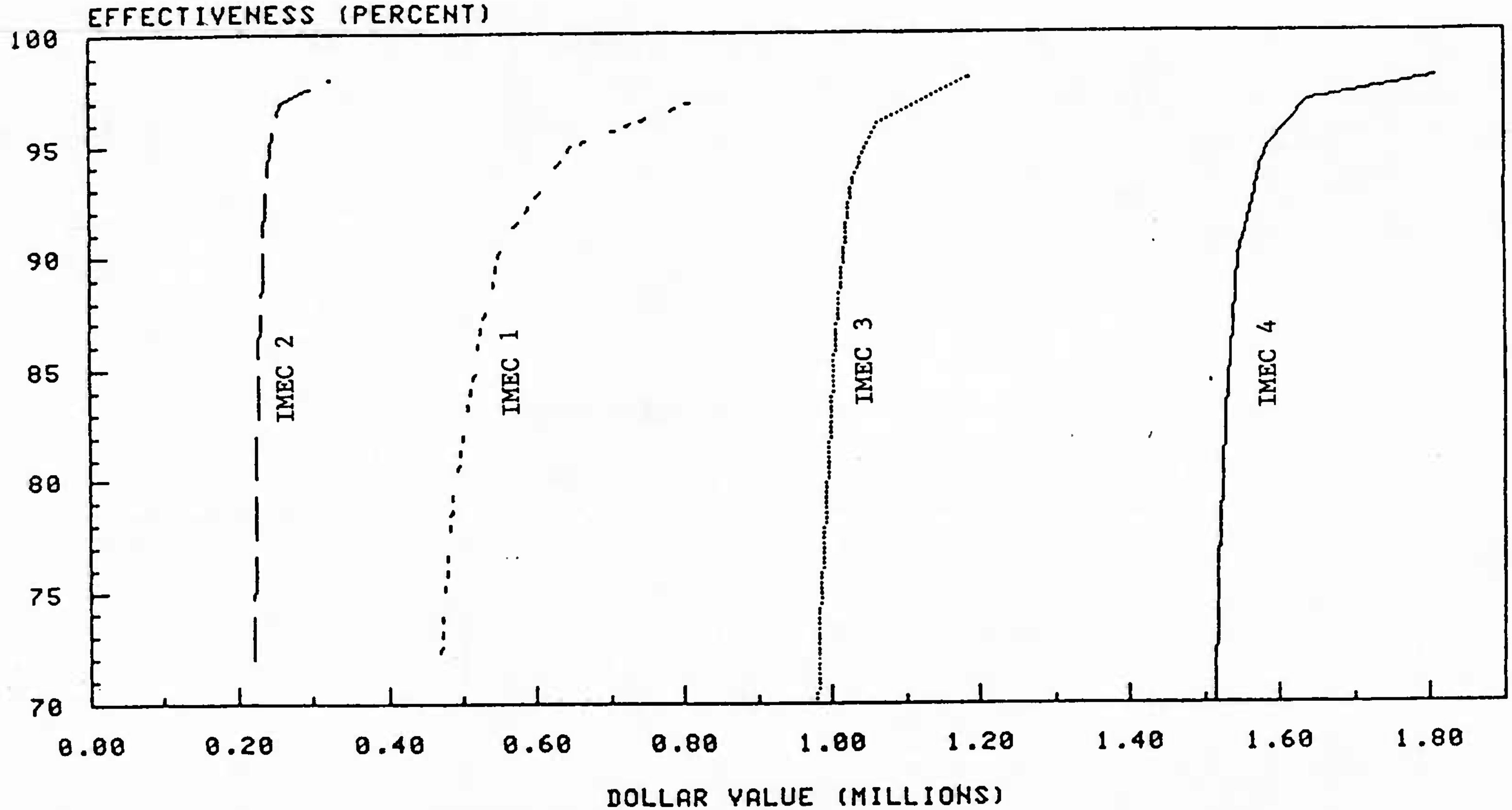


MOST COST EFFECTIVE GOAL BY IMEC:

1 - 90%
2 - 90%
3 - 95%
4 - 95%

AS-11 $ VALUE VERSUS PREDICTED NET REQUISITION EFFECTIVENESS

FIGURE 1



MOST COST EFFECTIVE GOAL BY IMEC:

1 - 95%
2 - 95%
3 - 95%
4 - 95%

AD/AR $ VALUE VERSUS PREDICTED NET REQUISITION EFFECTIVENESS

FIGURE 2

TABLES XIII and XIV compare Benchmark I (the current procedure), Benchmark III (no weights in risk equation for BRF items), NAVSUPSYSCOM proposed goals by IMEC, and the most cost-effective goals by IMEC, for the AS-11 and AD/AR, respectively. Each result is also broken down to reflect the impact by IMEC. For a .8M increase over the AS-11 current benchmark, the goals of 90%, 90%, 95%, and 95% for IMECs 1, 2, 3, and 4, respectively, provide one to two percentage point increases in overall effectiveness and one to four percentage point increases in separate IMEC categories. For no increase in dollar value over the AD/AR current benchmark, the separate effectiveness goals of 95% for each IMEC provide an overall increase in effectiveness of one to two percentage points and increases in separate IMEC categories of one to three percentage points.

TABLE XIII
AS-11 GOALS BY IMEC

ALTERNATIVE	IMEC	RANGE	$ VALUE	GROSS REQN EFF	MODEL REQN EFF
BENCHMARK I	TOTAL	21,551	9.5M	69%	82%
	1	9,817	2.9M		86%
	2	2,178	1.1M		65%
	3	4,899	3.4M		67%
	4	4,657	2.2M		84%
BENCHMARK III	TOTAL	21,551	9.4M	68%	81%
	1	9,817	2.8M		84%
	2	2,178	1.1M		64%
	3	4,899	3.4M		67%
	4	4,657	2.2M		83%
PREDICTED NET REQUISITION EFFECTIVENESS GOALS BY IMEC					
GOALS	TOTAL	21,551	9.7M	69%	83%
85%	1	9,817	2.9M		85%
87%	2	2,178	1.1M		67%
90%	3	4,899	3.5M		69%
92%	4	4,657	2.2M		84%
PREDICTED NET REQUISITION EFFECTIVENESS GOALS BY IMEC					
GOALS	TOTAL	21,551	10.3M	70%	84%
90%	1	9,817	3.1M		87%
90%	2	2,178	1.2M		69%
95%	3	4,899	3.7M		69%
95%	4	4,657	2.3M		86%

TABLE XIV
AD/AR GOALS BY IMEC

ALTERNATIVE	IMEC	RANGE	$ VALUE	GROSS REQN EFF	MODEL REQN EFF
BENCHMARK I	TOTAL	19,033	3.3M	33%	49%
	1	4,901	.5M		46%
	2	1,879	.2M		69%
	3	5,000	1.0M		65%
	4	7,253	1.5M		44%
BENCHMARK III	TOTAL	19,033	3.3M	33%	49%
	1	4,901	.5M		45%
	2	1,879	.2M		69%
	3	5,000	1.0M		65%
	4	7,253	1.5M		44%
PREDICTED NET REQUISITION EFFECTIVENESS GOALS BY IMEC					
GOALS	TOTAL	19,033	3.3M	33%	50%
85%	1	4,901	.5M		46%
87%	2	1,879	.2M		69%
90%	3	5,000	1.0M		66%
92%	4	7,253	1.6M		45%
PREDICTED NET REQUISITION EFFECTIVENESS GOALS BY IMEC					
GOALS	TOTAL	19,033	3.3M	34%	51%
95%	1	4,901	.6M		48%
95%	2	1,879	.2M		72%
95%	3	5,000	1.0M		68%
95%	4	7,253	1.6M		45%

Reference 6 of APPENDIX A indicates that a skewed distribution (e.g., Geometric, Exponential, or Poisson) is more appropriate than the Normal to model load list demand. Thus, we evaluated using the Geometric/Exponential (Geometric for items with QAD $\leq$ 1 and Exponential for items with QAD > 1) and the Poisson/Normal (Poisson for items with QAD $\leq$ 1 and Normal for items with QAD > 1) in combination with goals by IMEC and no range cut. We built the loads using the gross requisition effectiveness goals corresponding to the net requisition effectiveness goals shown in TABLES XV and XVI. We used gross requisition effectiveness goals because net requisition effectiveness goals are not appropriate for a model with no range cut; i.e., one item could produce the required net effectiveness. Current procedures for the AD/AR and AS use the Normal distribution for all items. TABLES XV and XVI show the results for the AS-11 and AD/AR, respectively.

TABLE XV
AS-11 ALTERNATIVE PROBABILITY DISTRIBUTIONS

ALTERNATIVE	IMEC	RANGE	$ VALUE	GROSS REQN EFF	MODEL REQN EFF
BENCHMARK I	TOTAL	21,551	9.5M	69%	82%
	1	9,817	2.9M		86%
	2	2,178	1.1M		65%
	3	4,899	3.4M		67%
	4	4,657	2.2M		84%
GOALS BY IMEC USING POISSON/NORMAL DISTRIBUTION					
GOALS	TOTAL	18,993	7.6M	66%	79%
85%	1	8,492	2.5M		83%
87%	2	1,969	.8M		63%
90%	3	4,568	2.5M		64%
92%	4	3,964	1.8M		77%
GOALS	TOTAL	20,186	8.4M	69%	83%
90%	1	9,042	2.8M		86%
90%	2	2,039	.9M		66%
95%	3	4,727	2.8M		67%
95%	4	4,378	1.9M		84%
GOALS BY IMEC USING GEOMETRIC/EXPONENTIAL DISTRIBUTION					
GOALS	TOTAL	32,384	8.7M	70%	84%
85%	1	11,973	3.0M		86%
87%	2	4,818	1.0M		71%
90%	3	8,770	2.7M		71%
92%	4	6,823	2.0M		85%
GOALS	TOTAL	37,716	9.7M	72%	87%
90%	1	12,995	3.3M		88%
90%	2	5,378	1.0M		74%
95%	3	10,572	3.1M		76%
95%	4	8,771	2.3M		90%

TABLE XVI
AS-11 ALTERNATIVE PROBABILITY DISTRIBUTIONS

ALTERNATIVE	IMEC	RANGE	$ VALUE	GROSS REQN EFF	MODEL REQN EFF
BENCHMARK I	TOTAL	19,033	3.3M	33%	49%
	1	4,901	.5M		46%
	2	1,879	.2M		69%
	3	5,000	1.0M		65%
	4	7,253	1.5M		44%
GOALS BY IMEC USING POISSON/NORMAL DISTRIBUTION					
GOALS	TOTAL	14,596	2.1M	31%	46%
85%	1	3,788	.4M		46%
87%	2	1,371	.1M		64%
90%	3	3,607	.6M		57%
92%	4	5,830	.9M		41%
GOALS	TOTAL	16,779	2.5M	33%	49%
95%	1	4,683	.6M		48%
95%	2	1,681	.2M		71%
95%	3	4,112	.7M		62%
95%	4	6,303	1.0M		44%
GOALS BY IMEC USING GEOMETRIC/EXPONENTIAL DISTRIBUTION					
GOALS	TOTAL	23,958	2.8M	34%	50%
85%	1	5,355	.5M		48%
87%	2	2,442	.2M		71%
90%	3	6,392	.8M		62%
92%	4	9,769	1.4M		45%
GOALS	TOTAL	29,381	3.1M	35%	52%
95%	1	7,119	.6M		50%
95%	2	3,368	.2M		77%
95%	3	8,069	.8M		67%
95%	4	10,825	1.5M		47%

TABLES XV and XVI show that Poisson/Normal distribution using the wholesale level goals is less expensive than the current benchmark but also gives lower effectiveness. TABLE XV shows that for the AS-11, the Geometric/Exponential distribution using the wholesale goals is $.8M cheaper than the current benchmark and provides up to a six percentage point increase in individual IMEC effectiveness. At the cost-effective goals, the Geometric/Exponential distribution is slightly more expensive ($.2M) but increases individual IMEC effectiveness by up to nine percentage points. TABLE XVI shows that for the AD/AR, the Geometric/Exponential distribution using the wholesale goals is $.5M cheaper than the current benchmark and provides up to a two percentage point increase in individual IMEC effectiveness. At the cost-effective goals, the Geometric/Exponential distribution is $.2M cheaper and provides up to an eight percentage point increase in individual IMEC effectiveness.

IV. SUMMARY AND CONCLUSIONS

Using the AD-44 and AS-11 as test ships, we evaluated alternative methods of implementing IMECs in the TARSLL model. We used the wholesale IMEC for the AD test loads, and a hull-tailored IMEC for the AS-11 test loads. Performance of the test loads was measured in terms of dollar value, range, and effectiveness when tested against MLSF demand data.

The alternatives of implementing IMECs that we tested were separate net requisition effectiveness goals by IMEC, range cuts by IMEC, minimum protection levels by IMEC for depth determination, and weights by IMEC in the risk equation.

For both the AS and AD/AR test loads, the range cuts by IMEC option gave the best gross effectiveness, but only with a range and dollar value much higher than the benchmark. Minimum protection level by IMEC was not cost-effective for the AS test load, but provided similar results as the benchmark for the AD test load. Weights in the risk equation of 1.0, 0.5, 0.1, and 0.01 for IMECs 4, 3, 2, and 1, respectively, were not cost-effective for either ship, while the weights of 4.0, 3.0, 2.0, and 1.0 for IMECs 4, 3, 2, and 1, respectively, provided similar results as the benchmark for the AS but were not cost-effective for the AD test load.

By adjusting parameters, it was possible to achieve similar results with any alternative. Goals by IMEC was the most cost-effective alternative common to both test ships. In addition to being the most cost-effective alternative, goals by IMEC provide the greatest flexibility to allocate dollar resources to more essential items.

For each IMEC, we graphed predicted net requisition effectiveness versus dollar value to determine what would be the most cost-effective goal by IMEC for each ship. The graphs indicated that separate net requisition goals by IMEC of 90% for IMEC 1 and 2 items and 95% for IMEC 3 and 4 items are the most cost-effective goals for the AS and separate net requisition goals by IMEC of 95% for each IMEC is the most cost-effective goal for the AD/AR. Using the goals by IMEC with the Geometric/Exponential distribution provides an even greater increase in effectiveness.

V. RECOMMENDATION

We recommend eliminating the current essentiality term from the TARSLL model risk equation. We also recommend computing the TARSLL depth using the Geometric/Exponential distribution with no range cut and separate gross requisition effectiveness goals by IMEC category.

APPENDIX A: REFERENCES

1. FMSO ltr 5250 9321/HML-E29/20 of 1 Feb 1985.

2. TARSLL IMEC Study mtg of 3 Apr 1985.

3. Operations Analysis Report 151.

4. Operations Analysis Report 158.

5. CNO ltr 4400 412E/5U394066 of 3 Jun 1985.

6. Operations Analysis Report 165.

APPENDIX B: IMEC DISTRIBUTIONS BY COG

AS-11 IMEC DISTRIBUTIONS BY COG

COG	1	2	3	4	TOTAL
	44				44
OC		1	1		2
OH		1			1
OX	1				1
OO	1				1
1H	8,295	3,633	4,240	3,195	19,363
1R	71	14	28	6	199
2F	23	23	37	1	84
2J	10		1		11
20	3				3
2R	2				2
2S	304	10	6	20	340
2W			1		1
2Z	65	8	14		87
4T		1			1
4Y	1		2		3
5L	43	3			46
5M	3				3
5N	5	40			45
5R	4			2	6
6A	1				1
6D	10				10
6H	2		94		96
6K	1				1
6R	1				1
6Y	9	7	1	1	18
7E	1		3		4
7G	552	364	415	425	1,756
7H	1,004	977	1,763	455	4,199
7R	20	14	6	1	41
7Z	71		4	1	76
8H		1	3		4
8X			4		4
9A	8		1		9
9C	3,364	1,638	2,231	4,026	11,259
9D	1,075		2		1,077
9F	41	20	25	6	92
9G	4,631	1,425	1,629	725	8,410
9H	108		1		109
9I	13	2	4	14	33
9J	7	2	5	4	18
9K	28	15	29	3	75
9L	1,713	38	2	1	1,754
9N	13,707	8,427	9,875	3,336	35,345
90	10	6	10		26
9Q	4,839	98	201	204	5,342
9S	11	2	1	2	16
9V	84	10	8	4	106
9W	13	2	1	2	18
9X	2				2
9Y	84	27	27	1	139
9Z	6,959	3,175	4,740	5,775	20,649
	47,244	19,984	25,415	18,210	110,853

AD/AR IMEC DISTRIBUTION BY COG

COG	1	2	3	4	TOTAL
	197	2			199
0C	8	2	3	2	15
0F		5	6		11
0G		3	11	3	17
0H		1			1
0Q			1		1
0X	5		1	2	8
1H	9,271	6,800	11,283	6,763	34,117
1R	113	34	70	43	260
2C	2				2
2F	11	3	31	13	58
2J			1		1
2R	1		1		2
2S	17	33	53	35	138
2T		1			1
2W	1				1
2Z	58	24	47	11	140
4R	1				1
4Y	1		1		2
5L		4		43	47
5M	3	7			10
5N	19	4	4	17	44
5R	20	12	17	8	57
6A	1				1
6C		1			1
6D	2				2
6H			3		3
6K	2				2
6R	3		1		4
6X	1		1		2
6Y	2	4	5	3	14
7E	4				4
7G	401	522	1,077	198	2,198
7H	1,269	1,364	2,796	1,770	7,199
7R	17	6	20	9	52
7Z	113	16	13		142
8A			1		1
8H	1		2		3
9A	16	32	23	28	99
9C	8,021	8,153	14,453	14,268	44,895
9D	194	1	10	5	210
9E	6	12	8	12	38
9F	44	55	49	18	166
9G	4,866	4,423	6,562	3,959	19,810
9H	28	11	11	9	59
9I	20	6	11	16	53
9J	7	6	17	6	36
9K	48	50	72	15	185
9L	419	10	26	43	498
9N	14,412	10,330	21,576	13,095	59,413
9O	23	24	51	24	122
9Q	3,505	233	697	897	5,332
9S	19	3	13	4	39
9V	204	72	58	270	604
9W	23	10	7	6	46
9X	2				2
9Y	157	94	172	23	446
9Z	10,262	9,331	17,054	19,315	55,962
	53,820	41,704	76,319	60,933	232,776

APPENDIX C: DISTRIBUTIONS OF E VALUES FOR BRF ITEMS

E	AS-11		AD/AR	
	FREQ	% FREQ	FREQ	% FREQ
.001-.009	131	1.6	108	1.4
.100-.199	15	.2	27	.4
.200-.299	12	.2	38	.5
.300-.399	11	.1	35	.4
.400-.499	28	.4	20	.3
.500-.599	41	.5	97	1.2
.600-.669	9	.1	21	.3
.670	6168	77.2	5093	65.4
.671-.699	274	3.4	236	3.0
.700-.799	317	4.0	449	5.8
.800-.899	133	1.7	181	2.3
.900-.998	164	2.1	704	9.0
.999	682	8.5	775	10.0

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